We would like to thank Reviewer 2 for their thoughtful comments and suggestions which are much appreciated and have helped to strengthen our manuscript. Note that all the revised figures referenced throughout the response can be found at the end of this document.

Overall, I found the paper well written and quite succinct. From a point of view on was there a substantial increase in our fundamental understanding into dune erosion, I was less convinced. Not much in the paper surprised me or told me something I didn't know, but more reaffirmed my understanding/observations/past work. That's not to say that more couldn't be presented to improve the paper and provide further understanding that I think is unique to modelling work as you have high resolution results that you can interrogate more than you have presented here. By presenting more and digging more into the results I think you could better answer your three objectives above. For example: Your dune profiles were very different and in XBeach, erosion occurs if a cell is determined to have been 'wet' so since your higher aspect ratio dunes had more sand closer to the dune toe, they would expect to have more erosion volumes by the nature of the model and not necessarily by a physical meaning. XBeach dune erosion is purely ad-hoc. If a cell is wet, it compares it to your wet slope and erodes it if it's above this critical value. Realignment can also take place if dryslp is exceeded. None of this is really based on physics of dune erosion. Dunes hold much larger scarps under active erosion (See Palmsten and Holman paper for examples but many others as well including work by Erikson and Hanson -> dune notching paper , Larson Erikson and Hanson (2004) and all the work on dune impact models (Overton et al) all show this). The sand is typically (from my experience using XBeach) also immediately moved offshore (to keep the wetslp low) so the feedback mechanisms we'd see in real erosion are not there where slumped sand protects the dune toe. The model has limitations and I can accept those but I think you need to acknowledge them a bit more here and realize what we can (and cannot) learn from these results. Consider the very different dune aspect ratios you are considering and the distribution of sand in the cross-shore, it would be good to see dune toe recession presented as well as you refer to volumes (which I also think are needed) but when you align toe,
heal, center, and with each of the aspect ratios you change the distribution of the volume in the dune. So small events will erode a lot when the toe is aligned because there is a lot of sand up close, but dx (dune toe erosion) might be similar and this is a key variable of interest to engineers/managers. The model is a grid so you are 'eating away' at the dune 1 grid point at a time as a function of the predicted TWL. Default dry slopes in XBeach are also quite flat compared to what would be capable in active dune erosion (see for example lab studies of Palmsten and Holman 2012,https://www.sciencedirect.com/science/article/pii/S0378383911001633; Palmsten and Holman 2011, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2011JC007083;Palmsten and Splinter 2016, https://www.sciencedirect.com/science/article/pii/S037838391600017X- this latter one explicitly looked at XBeach and my memory is that to match the lab data they used dryslp almost 4x the default value to allow for near vertical scarping)

Reviewer 2 suggested that we conduct additional analyses to better understand changes to the dune and beach morphology as a function of the dune aspect ratio. Following these suggestions, as well as those of Reviewer 1, we now include wave energy (directly outputted from XBeach) in our revised paper because it is related to impact hours (which were suggested by Reviewer 2), but provides more insight into the amount of erosion found in our simulations. We have also included analyses for the change in dune toe position as a function of dune aspect ratio and storm duration, as suggested by the reviewer. We do not include changes in beach width (suggested by reviewer 2) because it is independent of dune toe position. However (following our response to Reviewer 1), we have more clearly isolated the role that varying beach widths play in mitigating dune erosion (see page one of this response for details). Each of the analyses presented in the revised paper have been conducted using updated and improved parameterizations to XBeach following comments and suggestions by Reviewer 2. Details on this are provided in the responses below. Because these suggested changes are referenced throughout the review, we list the changes we have made to the paper in response to this review below:

- Updated the methods section (Lines 99-109) to describe the new metrics that we added to our analysis
- Updated the results section to include analyses of changes in the dune toe position (suggested by reviewer 2) and wave energy reaching the dune.
- Updated Figure 7 to only show results from the toes-aligned simulations where the different storm surge scenarios are presented in each column (rather than each row) and the rows each show a different metric as a function of dune aspect ratio and storm duration. In the top row we show volume loss, in the middle row we show change in the dune toe position, and in the bottom row we show the cumulative wave energy impacting the dune. Additionally, we have removed Figures and 9 from the submitted manuscript and replaced them with ones showing the same metrics but for the crests-aligned and heels-aligned simulations. Figure 11 shows this analysis for the fenced simulations.

These new analyses allow us to better describe not just the amount of erosion experienced by the dunes in our simulations but also the manner in which they were eroded (i.e., sediment piling up at the base of the dune via scarping versus sediment being transported offshore), adding greater depth and context to our analyses.

Here the reviewer also suggests useful papers that have indicated different XBeach parameter values, which may be more appropriate than the values we used with the simulations presented in the original manuscript. We re-ran the simulations with the new parameterization, described below and, which qualitatively confirm our original results but with some quantitative differences. The default values for wetslp and dryslp in XBeach are 0.3 and 1.0 respectively. The wetslp value we used is equivalent to that used by Palmsten and Splinter (2016) but with a dryslp of 4.0 instead of the default 1.0. To improve the model results and simulate better erosion physics with XBeach we re-ran the simulations using an improved setup with parameter values updated from those published by Splinter and Palmsten (2012) and Palmsten and Splinter (2016) The following values have either been changed from a previous non-default value or have been set from their default value:

- Changed *eps* from 0.05 to 0.1
- Changed *facSK* from 0.30 to 0.15

- Changed *dryslp* from 1.0 to 4.0
- Set *hswitch* to 0.10
- Set *hmin* to 0.01

We have added the following statement to the methods section detailing the changes we made to the parameterization and some of XBeach's limitations as detailed by the reviewer (revised manuscript lines 180-187):

"We used the XBeach (Roelvink et al., 2009) model to simulate the effects of the synthetic storms described in Section 2.2 on the profiles described in Section 2.1. We ran XBeach (version 1.23.5465) in 1D-hydrostatic mode with the break parameter set to roelvink_daly and the gamma parameter set to 0.52 to better capture the effect of swash processes on the reflective beach profiles (Roelvink et al., 2018) we also adjusted parameters related to wave breaking and dry sediment transport in order to more realistically simulate dune erosion processes given the tendency of XBeach to overestimate erosion with default settings (Palmsten and Holman, 2011, 2012; Palmsten and Splinter, 2016; Splinter and Palmsten, 2012). XBeach erodes the profile by comparing the slopes to the dryslp (if a cell is dry) parameter or wetslp (if a cell is wet) to determine how much erosion should occur to maintain these values. Palmsten and Holman (2011, 2012) show that wet sand can sustain much steeper scarps than dry sand. By using a particularly high value for the dry slope (dryslp = 4), we allow the dunes to maintain much steeper, and more realistic, scarps during the storms (Palmsten and Splinter, 2016). This realism allow us to better understand how the dune is eroding under collision when it is actively scarping during the storm by comparing dune toe migration to dune volume loss. A full listing of non-default parameters can be found in Table 2."

Can you also answer your objectives in terms of dune toe recession (as well as volume)to get a deeper understanding/picture of how dune aspect ratio effects overall erosion. One would expect that perhaps that higher aspect ratios might also have less dune toe recession as more sand is dumped onto the beach and may offer protection. I would also like to see plots of beach width change over the storm. This is some-thing you say is quite important to your results – wider beaches offer more protection. Something that other researchers have also shown to be quite important (eg. Plant and Stockdon, 2012. Probabilistic prediction of barrier-island response to hurricanes https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2011JF002326;Beuzen et al.2019.Controls of Variability in Berm and Dune Storm Erosionhttps://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019JF005184) Beach width(or safe corridor width) is also a key parameter that engineers/managers are wanting. How does your beach width over a storm impact on the erosion – does it need to be completely removed or only a certain percent for the dunes are vulnerable. I think if you could present your results looking at multiple parameters (volume, dune toe retreat, beach width change, dune impact hours) then the reader would get a much richer understanding of the impacts these changes to dune aspect ratio/beachwidth/storm duration had on the study. Volumes themselves only tell a small part of the story.

The reviewer suggests considering a number of other response in our simulations to further understand how dunes are eroding. For details regarding the changes stemming from this comment please refer to the top of our response to Reviewer 2. We have included dune toe position change and cumulative wave energy (related to impact hours) to our analysis to better understand changes in dune sand volume. We considered change in beach width but found it similar to change in dune toe position so we did not include this variable, although in our re-structured manuscript (see response to reviewer 1) we have included a figure (Figure 10) that demonstrates more clearly how the beach width and dune volume loss are related regardless of dune configuration.

Other Scientific Aspects to be considered: L35: "Considering that wave runup is most likely to impact the dune face (i.e., collision; Sallenger, 2000), which is more likely to affect the width of the dune rather than the height, is the most temporally common impact regime during a storm (Brodie et al., 2019; Stockdon et al., 2007), the width of the dune is an important predictor of how much erosion a dune might experience during a storm." I find this sentence really hard to read. Consider revising. As well, width won't be a predictor so much of the amount of erosion I would think, but of the erosive vulnerability of the dune itself. This paper might be of interest to you as it looks at both dune characteristics (height/width) and beach width in terms of erosion and flooding risks in storms: Leaman et al. (preprint, under review in Coastal Eng). A Storm Hazard Matrix combining coastal flooding and beach erosion. https://eartharxiv.org/repository/view/1753/

Regarding the suggestion to line 35: To clarify this statement and address the role of dune width we have changed these sentences in the introduction to (revised manuscript lines 39-41):

"Considering that wave runup is most likely to impact the dune face, collision (Sallenger, 2000) – which is more likely to impact the width of the dune rather than the height – is the most common impact regime during a storm (Brodie et al., 2019; Stockdon et al., 2007) and thus the width of the dune is likely to be an important predictor of how vulnerable the dune is to erosion during a storm (i.e., Leaman et al., 2020)."

L171: I am a bit concerned about leaving all other XBeach parameters as default as many studies have shown this isn't appropriate outside of the highly dissipative beaches for which the model was originally designed (along the Dutch coast). Leaving all other parameters as default has implications between overwash and collision regime erosion estimates as noted by previous researchers such as Passeri et al. and Simmons et al.. Not accounting for these processes will impact on your results. Why weren't these considered?, even is the cases were limited where overwash did occur? Others have also shown sensitivity of the erosion to parameters. Eg references below(note this isn't a complete list, just ones I could think of off-hand). Passeri et al. The influence of bed friction variability due to land cover on storm-driven barrier island morphodynamics https://www.sciencedirect.com/science/article/pii/S0378383917301114Simmons et al.Calibrating and assessing uncertainty in coastal numericalmodels https://www.sciencedirect.com/science/article/pii/S0378383916303234#f0030C4 Splinter and Palmsten. Modeling dune response to an East Coast Lowhttps://www.sciencedirect.com/science/article/pii/S0025322712002034

We agree that XBeach cannot appropriately simulate behavior on reflective beaches in its default state. To account for this, we used model parameters values published in Roelvink et al. (2018) who found good agreement with field data from Duck, NC by setting the breaker formulation to “roelvink_daly” and the value of gamma to 0.52 for simulations. Additionally, our revised manuscript includes results with simulations from the updated parameterization described above (Lines 40-42, Table 1) to more appropriately simulate dune erosion. The reduction in erosion using these new parameterizations has eliminated instances of overwash from our simulations, which is consistent with the lack of overwash in our study site during the survey period of 2016-2020, so tuning the model for collision appears to be appropriate in this case.

L183: “or when dunes are located closer to the shoreline (represented by the dune toes-aligned scenarios; Figure 7).” I am a bit confused by this as the effect of beach width would be shown not when the dune toes were aligned (and all beaches had the same beach width) but instead when the dunes were aligned at their crest or heel, which then changes their beach width. Ideally you should be comparing the cases for the same dune aspect ratio at these three positions to determine if effect of beach width. And this is repeated for each of the dune aspect ratios. This would be an interesting thing to see in my opinion (same dune aspect ratio plotted for the 3 positions within your dune toe, heal, crest align) to see how BW effects erosion for the same dune. Wider beaches offer a big buffer of sand that must be eroded before the wave action can get to the dune and frictional damping of the runup would also occur, lessening the probability of a dune experiencing wave impacts. Looking at dune impact hours could be interesting and provide some good insight here.

In the revised version of the manuscript we have addressed this concern (brought up by both Reviewer 1 and Reviewer 2) by including a figure (Figure 10) that directly compares the beach widths for the crests-aligned and heels-aligned simulations to the amount of volume loss between the crests-aligned and heels-aligned simulations with their corresponding toes-aligned simulations. The toes-aligned simulations are not included in this analysis because the beach width is the same for all the profiles such that those simulations would plot as vertical line for all toes-aligned simulations. This allows us to isolate the role of the beach width and demonstrate how much erosion is prevented for a given beach width regardless of the dune configuration. Additionally, we have included wave energy into our analysis throughout the results section to consider the amount of wave action reaching the dune (more impact hours, the metric suggested by Reviewer 2, leads to more cumulative wave energy reaching the dune).

L185: “situated farther from the shoreline (dune heels-aligned)” as above, I don’t see how having the dune heels aligned also indicates they are further from the shorelines as each of these cases would have a different beach width”

We agree and removed the parenthetical “(dune heels-aligned)” to make this sentence easier to understand and more accurate. The dunes that were farther from the shoreline experienced less erosion than those that were closer to the shoreline; The dunes fronted by the widest beaches are found in the heels-aligned configuration as a consequence of how the synthetic profiles were configured (Figure 2).

L241: "Additionally, the sensitivity of the dune to decreases in storm duration was inversely proportional to the beach width such that dunes fronted by wide beaches were noticeably less sensitive to increases in storm duration than dunes fronted by narrow beaches (Figure 9)." – It would be great to see figures that show beach width change over the storm.

Figure 10 in the revised manuscript shows the reduction in volume loss between the crests- and heels-aligned simulations and their equivalent toes-aligned simulations as a function of pre-storm beach width and for different storm durations. The restructured manuscript no longer includes this sentence or paragraph but in our revisions to the paper (Lines 265-310) we more clearly isolate and analyze the relationship between beach width change and dune volume loss.

Specific Minor Editorial Comments: L75: 'aspect ratio' is repeated twice

L91: replace 'Dtoe' with 'Dlow' to match figure 1 and to remove confusion as I believe that Dlow=Dtoe.

L95: "Given that Dlow was held constant across all simulations" I think should be "Given that prestorm Dlow was held constant across all simulations".

L147: remove '.' in 'approximately.'

We appreciate that Reviewer 2 also pointed out some grammatical and punctuation errors, which we have addressed in the revised version of the manuscript.

Overall, I think the paper could be improved to provide a fuller understanding of the complexities of dune erosion and how dune aspect ratio, beach width and storm duration/intensity impact on the model results. I have provided a number of example references to consider, but I'd like to acknowledge here that these are limited to what I could recall off hand rather than providing a complete list of relevant resources. Please consider these as examples and you might find more suitable ones within these papers as well

Thank you very much for the references and kind comments of our paper.

The following figures can be found in the revised version of the manuscript referred to in the responses to the reviewers. Note that figure numbers refer to their placement in the manuscript.

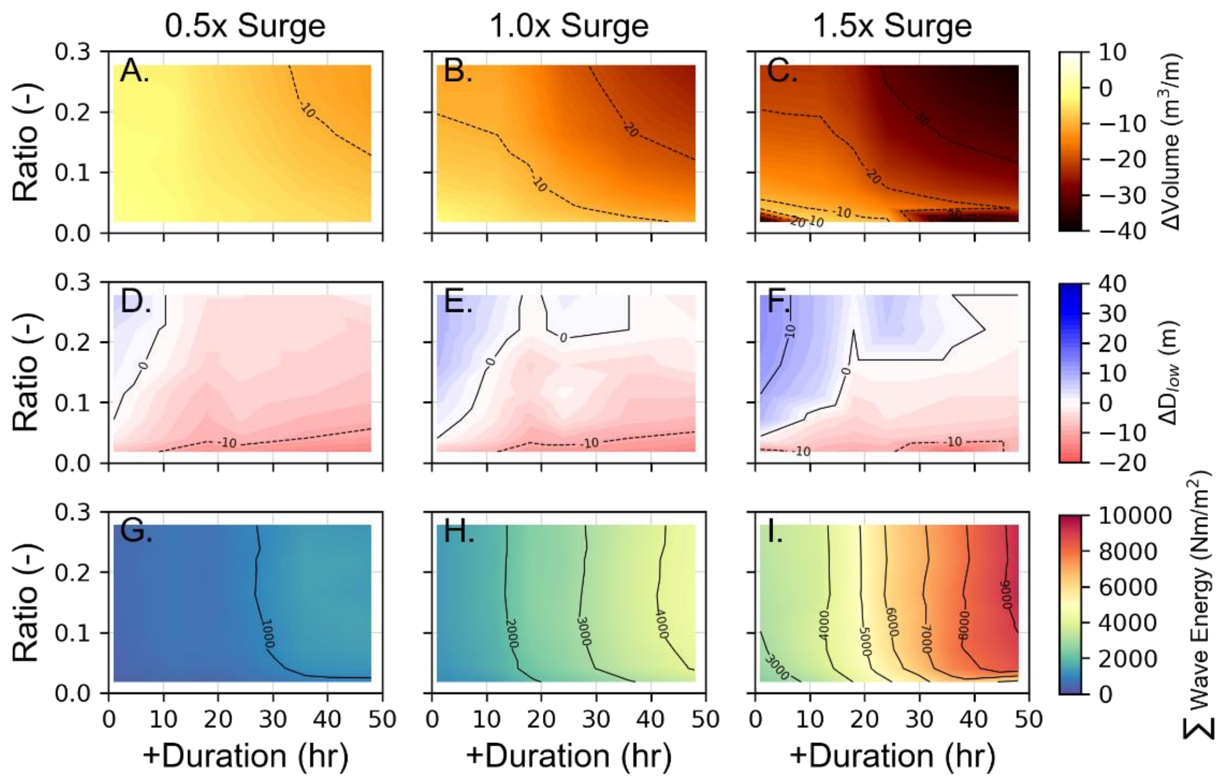

Figure 7: Dune aspect ratio versus storm duration for simulations with toes-aligned (controls for beach width/slope and initial dune volume). Each column represents a different storm surge level (increasing left to right). The top row (A, B, C) shows the change in dune volume, the middle row (D, E, F) shows the change in dune toe position (negative values indicate landward erosion), and the bottom row (G, H, I) shows the cumulative wave energy impacting the dune.

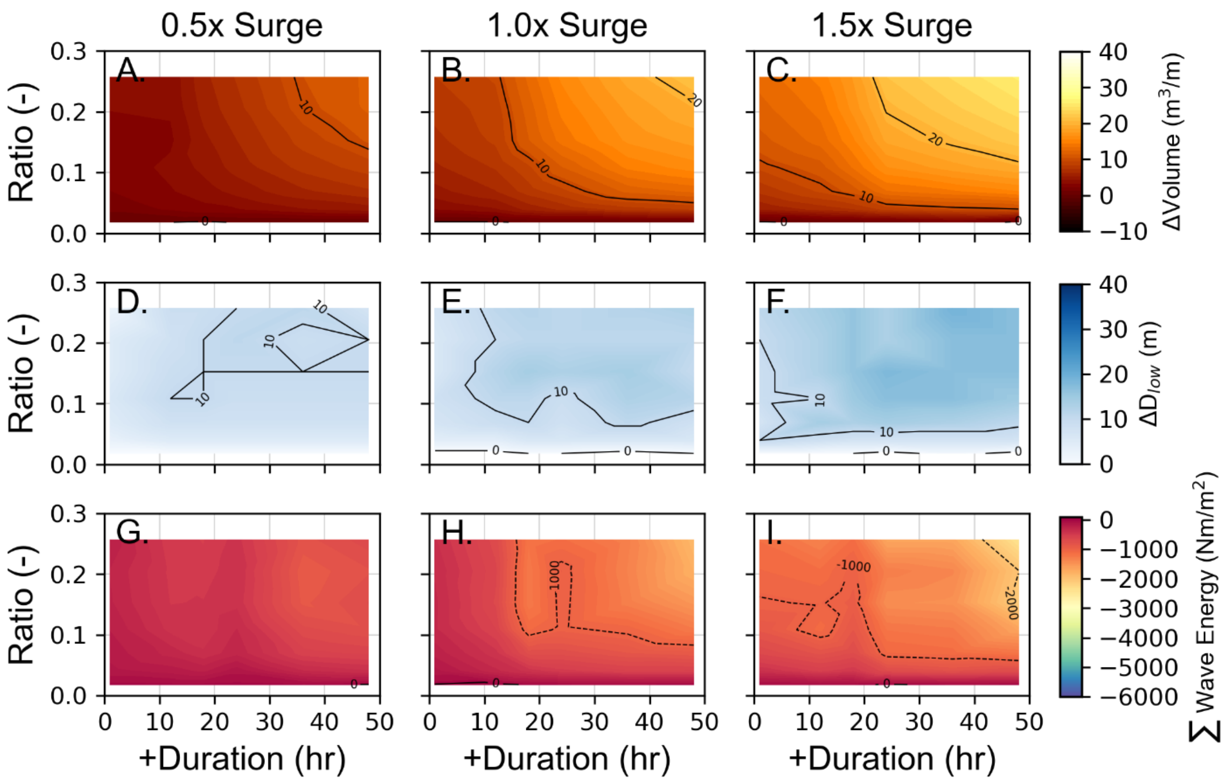

Figure 8: Dune aspect ratio versus storm duration for simulations with crests-aligned. The values from the equivalent simulations with the dune toes aligned have been subtracted from the crests-aligned simulations to highlight the influence from the varying beach widths in the crests-aligned simulations. Each column represents a different storm surge level (increasing left to right). These values represent a comparison relative to the toes aligned simulation (where beach width is controlled for) such that the top row (A, B, C) shows the amount of volume loss prevented by the wider beach in these simulations, the middle row (D, E, F) shows the additional dune toe progradation induced by the wider beach width, and the bottom row (G, H, I) shows the reduction in wave energy reaching the dune due to the wider (and thus lower sloping) beach.

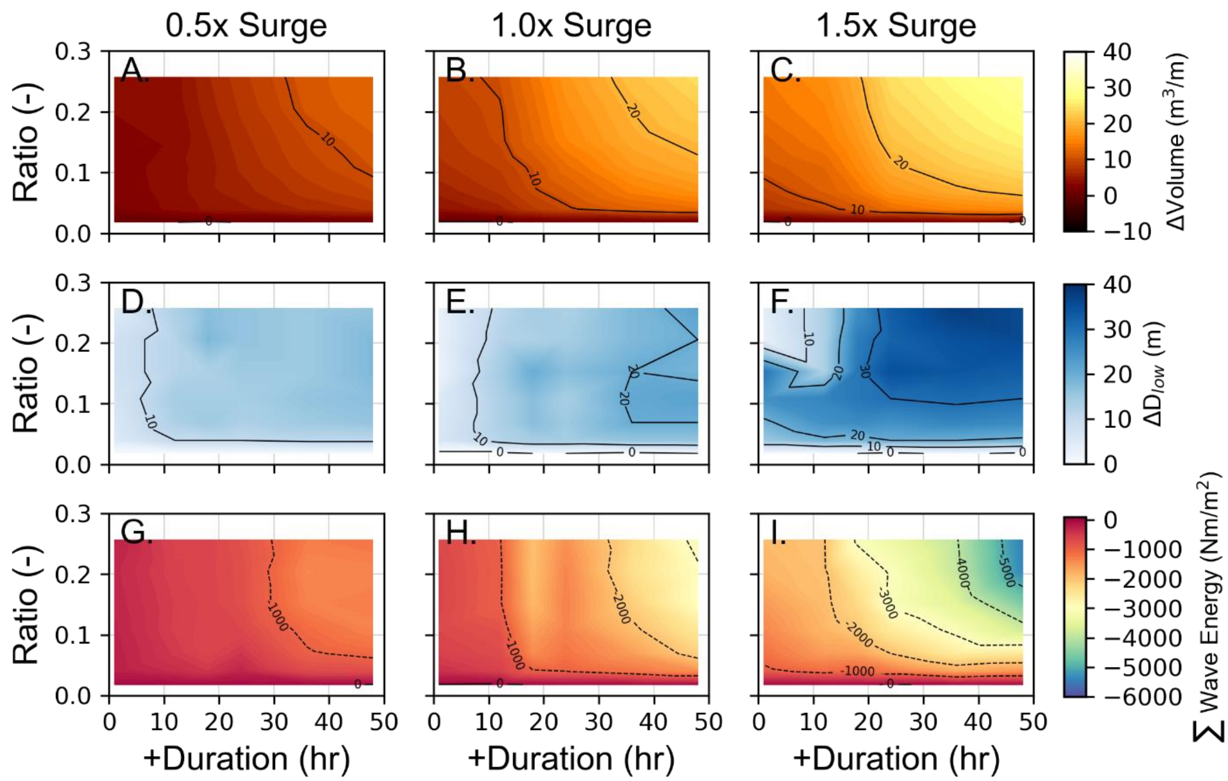

Figure 9: Dune aspect ratio versus storm duration for simulations with heels-aligned. The values from the equivalent simulations with the dune toes-aligned have been subtracted from the heels-aligned simulations in order to highlight the influence from the varying beach widths in the heels-aligned simulations. Each column represents a different storm surge level (increasing left to right). These values represent a comparison relative to the toes-aligned simulation (where beach width is controlled for) such that the top row (A, B, C) shows the amount of volume loss prevented by the wider beach in these simulations, the middle row (D, E, F) shows the increase in dune toe progradation induced by the wider beach width, and the bottom row (G, H, I) shows the reduction in wave energy reaching the dune due to the wider (and thus lower sloping) beach.

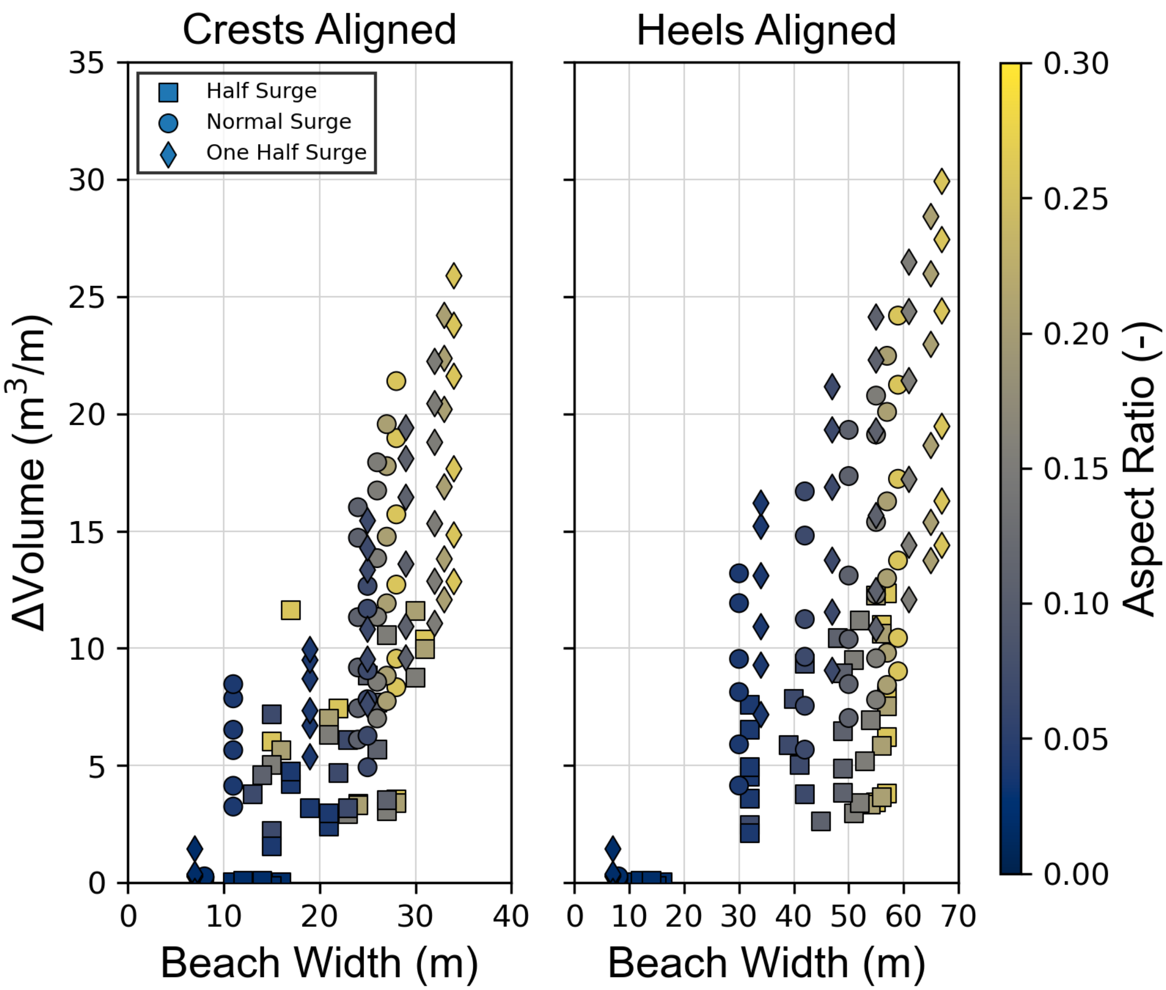

Figure 10. Volume loss from the crests-aligned and heels-aligned simulations minus volume loss from the equivalent toes-aligned scenarios versus the initial beach width for the crests- and heels-aligned simulations. The color corresponds to the dune aspect ratio and the shape corresponds to the surge level.

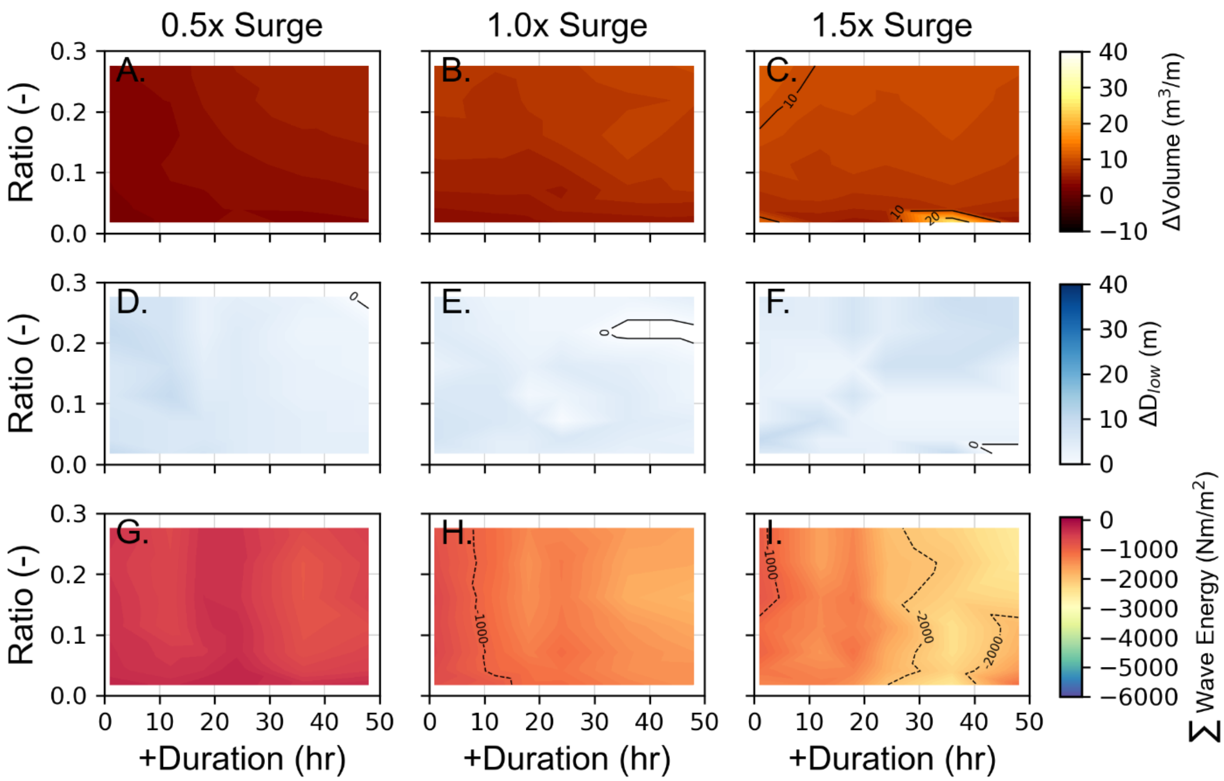

Figure 11: Dune aspect ratio versus storm duration for simulations with sand fences. The values from the equivalent simulations with the dune toes aligned have been subtracted from the fenced simulations in order to highlight the influence from the presence of the fenced dune seaward of the natural dune. Each column represents a different storm surge level (increasing left to right). These values represent a comparison relative to the toes-aligned simulation (where beach width is controlled for and there isn't a fenced dune) such that the top row (A, B, C) shows the amount of volume loss prevented by the fenced dune in these simulations, the middle row (D, E, F) shows the increase in dune toe progradation induced by the fenced dune, and the bottom row (G, H, I) shows the reduction in wave energy reaching the dune due to the fenced dune.